Space Weather Technical Forecast

Issued on Sunday, 28 August 2022 at 12:21 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares (R1-R2) likely 28th, 29th with slight chance X-class flares (R3). G1 Minor Storm likely with CME glance late 28th or early 29th. Chance of further Minor Radiation storms (S1).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate, with the background X-ray trace at GOES16 residing at C-class levels. Several M-class flares were observed from AR3088 (Ekc/Beta-Gamma) nearing the southwest limb, with peak flare M1.8 at 28/1558 UTC. AR3089 (Eki/Beta-Gamma-Delta) in the southeast, whilst less active, is another region of note, with some recent growth observed, including the emergence of an negative polarity spot near its positive trailer, resulting in the subsequent small delta spot development. There are three other sunspot containing active regions, however these are all smaller, simpler and currently stable. No Earth-directed CMEs were observed occurring in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was indicative of the transition into the fast wind from CH18/-. Solar winds rose from background 350km/s to become slightly elevated with peak 450-500km/s, whilst density fell from above average to average levels. The total interplanetary magnetic field (IMF), Bt, was at moderate levels (10-14nT), but eased to mainly weak at 5-10nT from 27/2030 UTC. The north-south component, Bz, was variable ranging +10 to -10nT at first, but eased from 27/2030 UTC to -6nT to +8nT. The phi angle was negative (towards the Sun) throughout. Geomagnetic activity was Quiet to Unsettled, with one Active interval (27/1200-1500 UTC)

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV), as measured by GOES-16 was at S1/Minor Radiation storm levels until 28/2145 UTC, with peak 27.5 pfu, then gradually eased. The high energy electron flux (greater than 2 MeV) was at High levels, with a peak of 1760pfu at 27/1315UTC observed by GOES-16, although this may have been influenced by some contamination from the high energy protons. This then fell to Background levels by 27/1445UTC. The 24-hour integrated electron fluence started the period above the Active threshold (1e8 integrated pfu) but fell below this level by 27/1800 with 2.39e7 integrated pfu observed at 28/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Further M-class flares are likely with a slight chance of an X-class flare. A gradual decline in solar activity is expected later in the period as AR3088 rotates off the southwest limb, although AR3089 in the southeast will need monitoring for any further development.

Solar Wind / Geomagnetic Activity: A moderately fast CME generated from the M4.7 flare of AR3088 on 27 Aug has the potential to give a glancing arrival 29/0100 UTC +/- 9 hours. Ongoing coronal hole fast wind enhancements are possible from CH17/- and CH18/+ during day 1 and 2 (28th and 29th), with the elevated solar winds only gradually easing day 4 (31st) onward. Geomagnetic Activity is expected to be Quiet to Unsettle at first, with a chance of Active from any transition from CH17 to CH18 fast winds, and with G1/Minor Storms likely with a chance of G2/Moderate storms from any CME glance. Mainly Quiet geomagnetic conditions expected by

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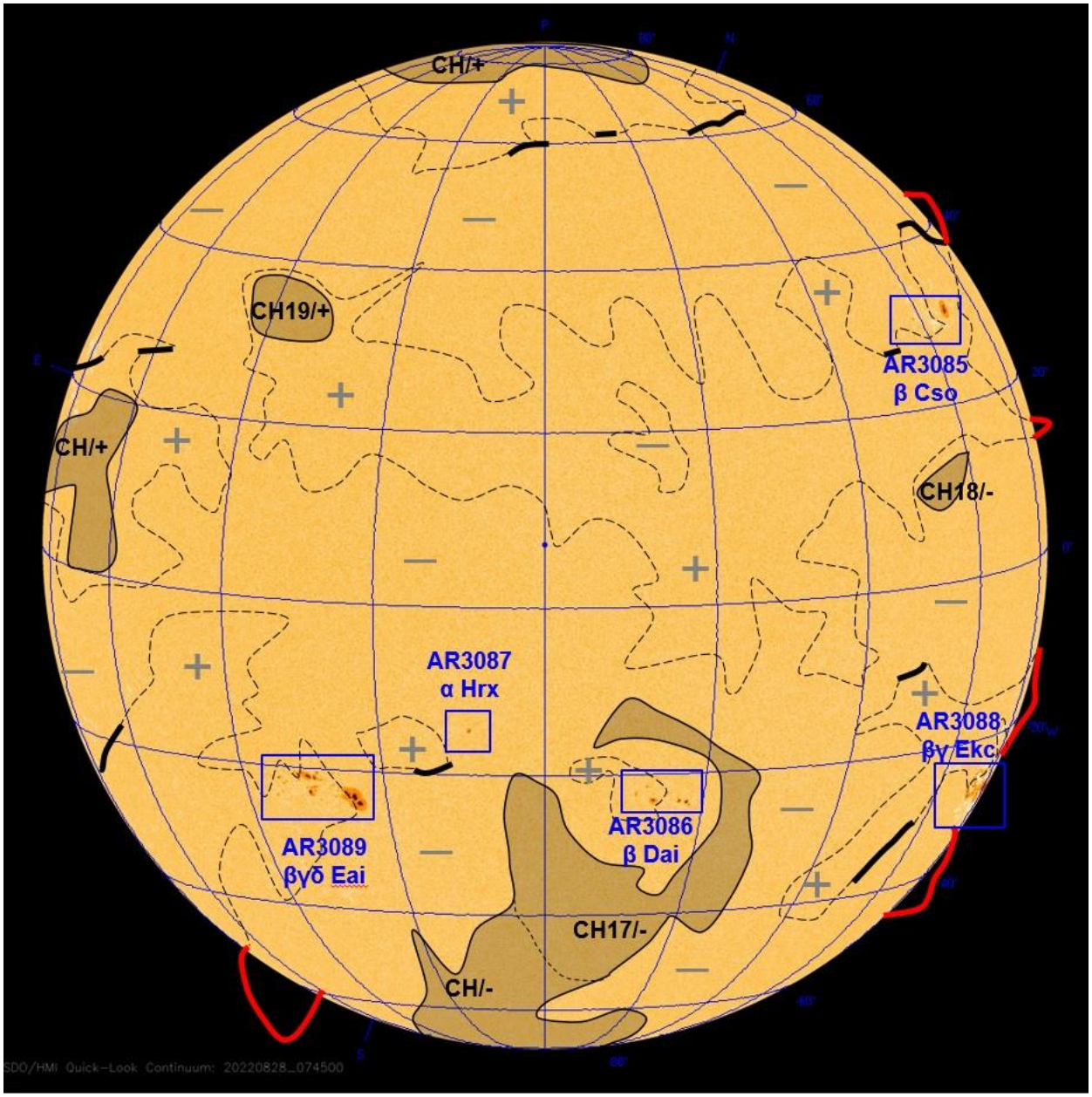
day 4 (31st)

Energetic Particles / Solar Radiation: High energy protons (greater than 10MeV) are expected to continue gradually declining, but with a chance of further enhancement, mainly from any notable flares from AR3088 days 1-3 (28th-30th). The high energy (greater than 2 MeV) electron flux forecast is expected to remain mostly at background, but likely rising again to Moderate, perhaps peaking High, once any fast wind enhancement or CME influence fades later day 2 and day 3. The associated 24 hour fluence is excepted to remain below the Active (1e8 integrated pfu) threshold, but with a chance of rising above by the end of the period

Figure 1. Solar Analysis Valid 28/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The M4.9 flare of AR3088 on the 27th, produced a relatively fast CME, leaving the Sun at 1250 km/s, This has been analysed as giving a mainly glancing impact at 29/0100 UTC +/- 9 hours. This has relatively low confidence however, with much of the material expected to pass ahead of Earth.

Earth is currently within the fast wind of CH18, a positive polarity hole, but is soon expected to transition into the fast wind of CH19, a negative polarity hole, either later day 1 or during day 2 (28th or 29th). The solar sector boundary crossing (SSBC) when this transition occurs may give some increased geomagnetic activity, especially if alongside the CME arrival. This is a broad feature, with elevated solar winds then expected to persisted until day 4 (31st), similar to persistence, which is currently giving good guidance.

Quiet to Unsettled conditions expected, with Active intervals from the transition into CH18 either later day 1 or day 2 (28th or 29th). However CME arrival is likely to bring G1/Minor Storm either late day 1 or more likely early day 2, with a chance of G2/Moderate Storms. Mainly Quiet conditions expected by day 4 (31st).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	60	10	1
Strong	G3	No	5	15	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
27/0230 UTC	Partial	M4.7 flare of AR3088	SW	1250	29/0100 UTC +/- 9hrs	Glancing Blow. Most material missing.

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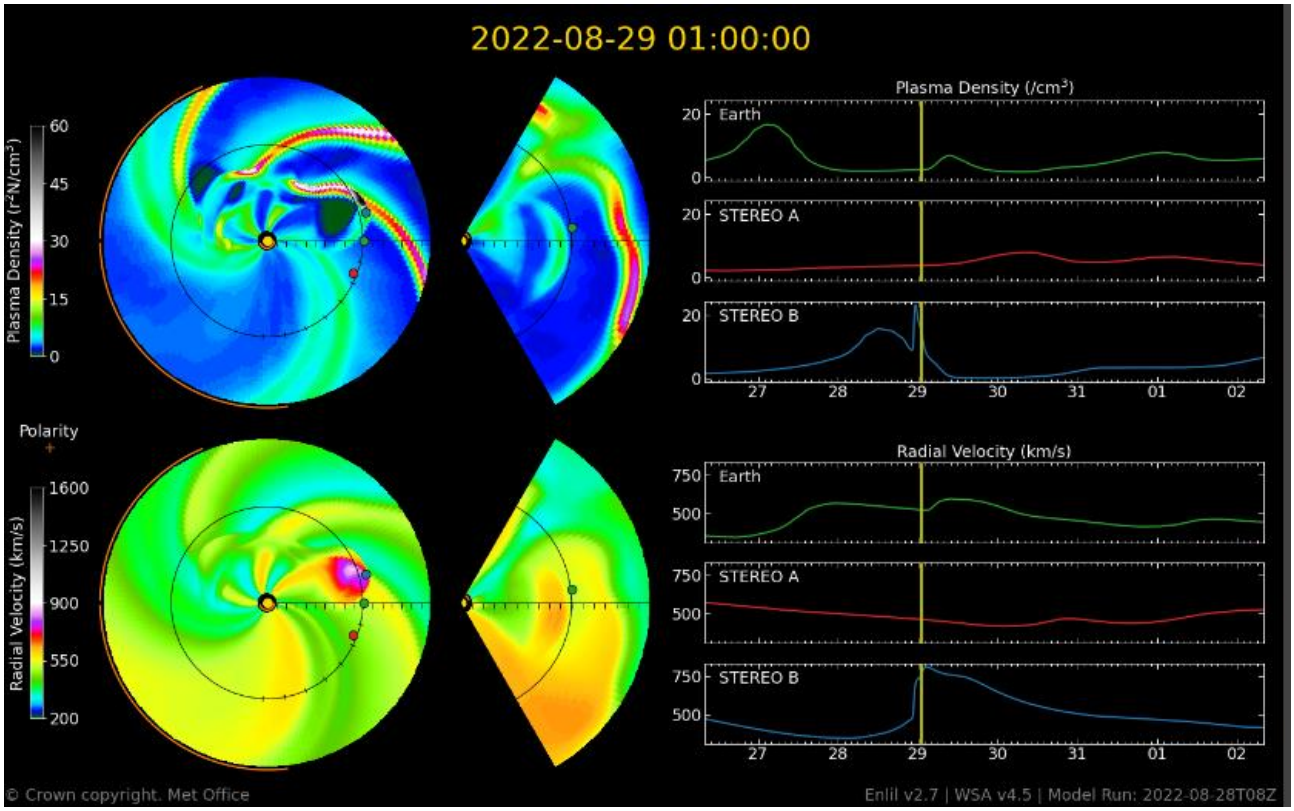
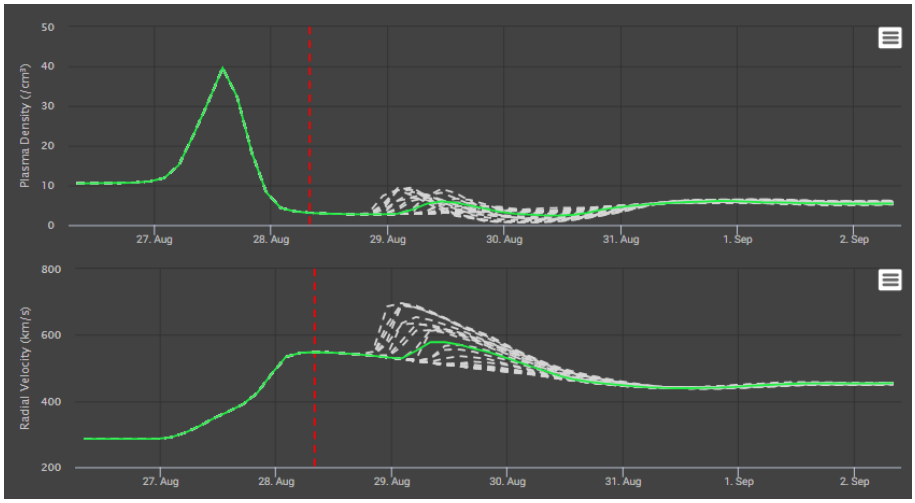
Figure 2: Enlil and ensemble showing likely arrival of CME





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Radio Blackouts - X-Ray Flares:

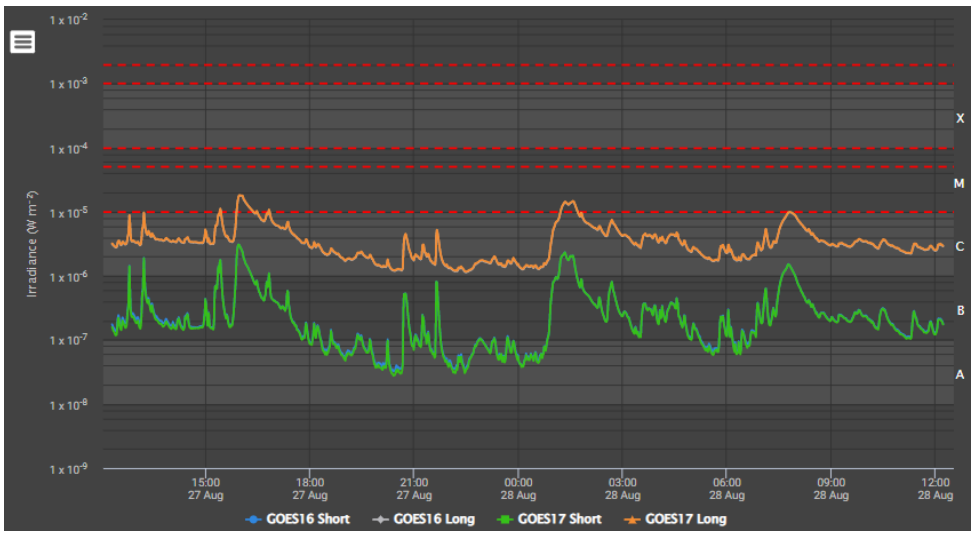
Solar Activity remains Moderate with several M-class flares observed, all from AR3088 Ekc/Beta-Gamma. This region is now very close to the southwest limb, and expected to move over it early day 2 (29th), although any notable flaring has the potential to still impact Earth until day 3 (30th), due to the magnetic looping above the spot. Due to its location, this spot is now impossible to accurately analyse, so its previous assessment will remain valid until it rotates off the disc, with further M-flares likely from this region, and a chance of X-class flares.

AR3089 (Eki/Beta-Gamma-Delta) in the southeast has also seen some increased magnetic complexity with the emergence of an opposite polarity sunspot near its main positive trailer spot, along with a proliferation of other small spots. This has resulted in the formation of a small delta spot. Furthermore, this region has a history of higher M-flares (R2) flares (on the 26th) and any further growth will also give a risk of Moderate to Strong flares. However, no significant activity has currently been observed, since the 26th.There are three other sunspot regions on the disc, however these are smaller and simpler.

Overall further M-flares are likely with a slight chance of X-calls flares. This falls day 3 (31st) once AR3088 has completely rotated over the limb, but still with a chance of further M-flares, mainly due to AR3089.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	75	60	30	30
Very Active	R3 to R5 X Class	No	20	15	5	5

Figure 3: GOES-16/17 X-ray Flux



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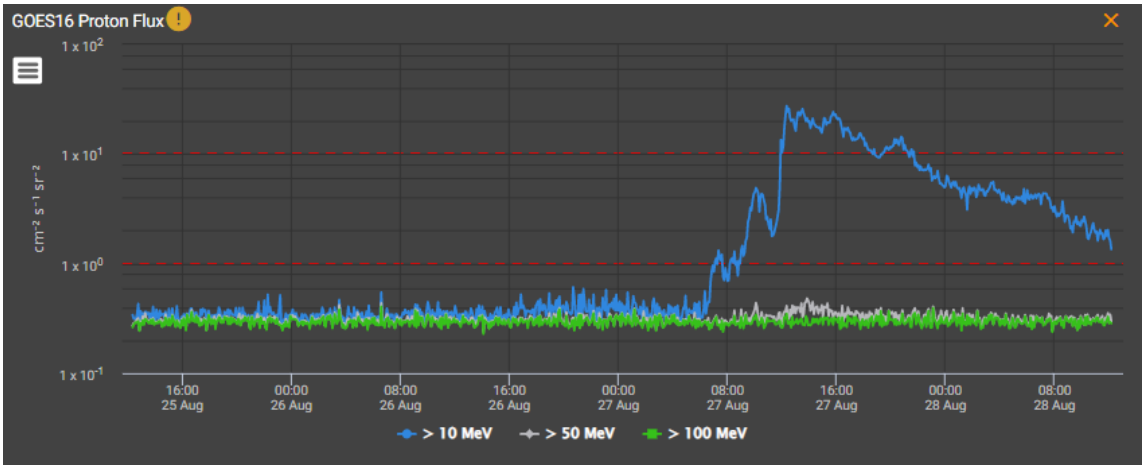
Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) is currently gradually declining towards background, after reaching the S1 level due to an M4.7 flare from AR3089 on the 27th, with a peak of 28pfu at 27/1220UTC.
This shows the potential for any flaring from this active region to giving a chance of further S1 or greater through the coming days. Although this region is expected to rotate off the visible disc early on the 29th, with a subsequent gradual reduction in proton storm risk as it moves further around the far-side. Although any far-sided flares can still result in an increase in proton flux day 3 (30th).
There is also further slight risk of proton storms as AR3088 moves into the western disc, and this region will need to be monitored for further development.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	25	25	20	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 >10MeV, >50MeV and >100MeV Proton Flux for the last 3 days.



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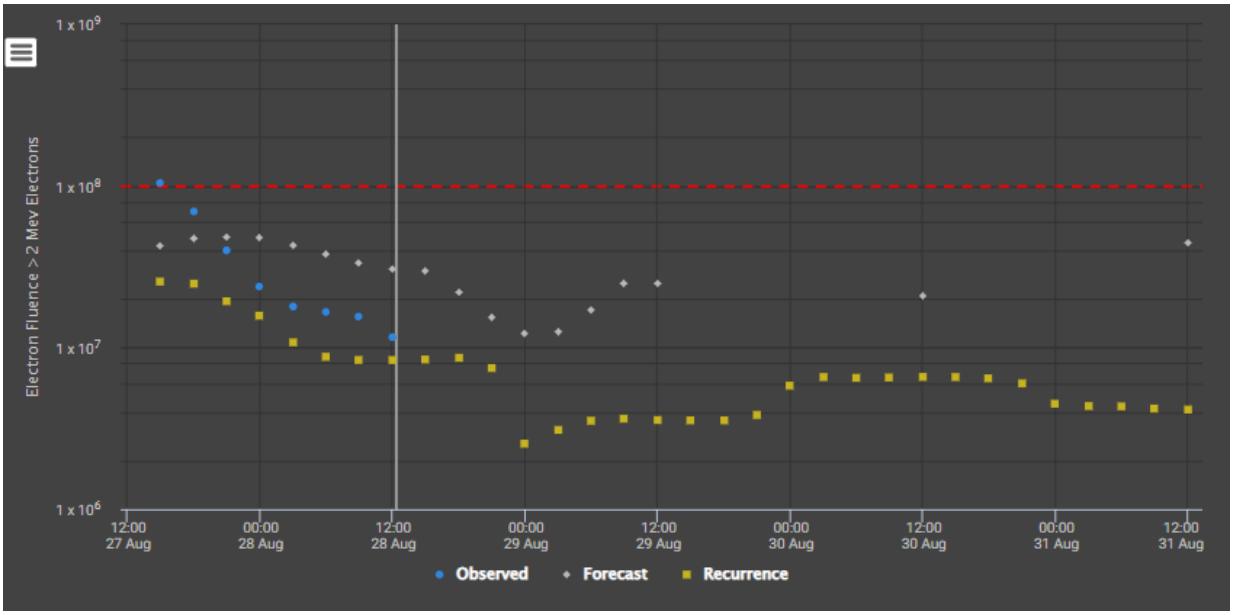
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux as observed by GOES-16, has remained at background after recent solar wind enhancement and proton storming. Arrival of the expected glancing CME overnight day 1 into day 2 (28th or 29th), alongside the transition into the fast wind of CH17, does have the potential to increase electron flux again once any subsequent geomagnetic activity subsides. However persistence from the previous rotation, suggests very little electron flux enhancement is likely from the fast wind of CH17.

Consequently, the associated 24 hour electron fluence is expected to remain below the Active threshold, with only a slight chance of rising above, mainly day 3 (30th) onward. This supported by REFM, although this model doesn't take account of any CME arrival or upcoming fast wind enhancement, so is likely giving poor guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	1	10	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 Electron Fluence with REFM and Recurrence.



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